Geographic Information Technology Institutionalization in the Nation's States and Localities

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Abstract

A leading challenge for the nation's state and local governments in the 21st century will be to effectuate and institutionalize coordinated approaches to geographic information technology (GIT), including remote sensing, geographic information systems, and use of the Global Positioning System (GPS). GIT promise, and growing and converging adoption, demands interorganizational cooperation within and among governments to best serve the public. While GIT largely began with the federal government, public policy and data needs have appropriately shifted focus to the nation's states, and particularly local governments. This paper reviews known conditions in the nation's states and localities, including the incidence of GIT, and GI/GIT authorizing direction, coordination groups, and offices. Government-wide GI/GIT roles, responsibilities, and activities also are described, including known state GI/GIT assistance for localities. The paper concludes with recommended national policy and institutional issues warranting investigation by governing leaders and GIT professionals in the 21st century.

Introduction

The beginning of the 21st Century—popularly termed as "Y2K"—can be a once-in-a-lifetime opportunity to take stock of one's life, career, profession, discipline, and personal perspectives and viewpoints shaping future directions. For those of us working in geographic (or spatial or geospatial) information (GI) and related technology (GIT), it is a wonderful time to assess progress and prepare for the future.

Working with GIT largely means we share a "geo-paradigm." Most of us feel it in a very personal way—in fact, analogous to religion. We reflect back years, even decades, to remember the month, day, or even the moment when we "got it." Those interested refer to Thomas Kuhn's *The Structure of Scientific Revolutions* (Kuhn, 1962) and related works to better understand this phenomena in the context of similar influences on change in science and society.

Individual personalization of a "geo-paradigm" has helped create what has been termed a "GIS community." Strong personal commitment and dedication typifies us, particularly public servants, and seems unparalleled in other fields. While we share this perspective, we have a unique view and approach based on individual background and experience that lets us contribute to society in different personal and valuable ways. Outsiders even recognize that GIT professionals often will "go the extra mile" to do what's necessary to help meet the task at hand, whether it be to apply GIT in growth or land-use planning, disaster response, understanding environmental or social conditions, or data interpretation, classification, or application.

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GIT professionals also adapt to new and changing GIT, increasingly recognized to include a melding of geographic information systems (GIS), remote sensing from satellites, airplanes and other instruments, image processing, and satellite positioning through the Global Positioning System (GPS). Yet, definitional differences and common understanding of terms seems to be a key challenge for the GIS community as we enter the 21st Century. For example, the terms geographic, land, cartographic, spatial, and geospatial data and information have been used in differing statutes among the states, causing confusion both within and outside our community. While these differences continue to challenge us (such as in the licensing issue), the trend is clearly toward a broadening conceptual definition of GI to include virtually all data that can be referenced by location, regardless of format.

Definitional challenges pale in importance when considered in the broad context of the "information age," and society's increasing dependence on many aspects of information technology (IT). To me, our shared geo-paradigm underlying the use of GIT remains conceptually unparalleled compared to other IT. A recognized trend today is for GIT to be conceptually and organizationally subsumed GIT under IT. Looking to the 21st Century, GIT will likely become part of a suite of IT ubiquitously available to many users ("like word processing"). However, I maintain that the geo-paradigm must and will strengthen because it represents a fundamental perspective in the evolution of societal and governing approaches to adapt to change and prepare for the future. Geography represents a heretofore undeveloped reference and foundation to link much disparate data in order to improve governance and to benefit society. Several converging governing and societal trends, in addition to technological advancement, suggest the growing emergence of—and growing need for—this geo-paradigm and GIT use in governance today.

For example, more and more disparate governments recognize that they must work together "on the ground," particularly when they share jurisdiction over or operate in the same or nearby areas. Several examples of this need are evident, such as local water and fire departments that must communicate about and coordinate the operability of fire hydrants, and street and utility departments that should coordinate maintenance and repair work in the same rights-of-way. "Environmental justice" also encourages governments to employ geographic perspective in making fair and equitable decisions.

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Some recent initiatives to geographically coordinate the work of multiple organizations and operations include "one stop shopping" or permitting, "common points of presence," and "place-based decision making." Moreover, the federal government is devolving roles and responsibilities to state and local governments.

However, this geo-paradigm continues to be lacking today in many cases. For example, several utilities located in a single right-of-way may not be aware of each other, causing breakage, disruption, and significant loss of property and even human life. Sometimes buildings are inappropriately built crossing a property line or on top of a contaminated area or a utility line, also causing harm to occupants. Such mistakes are often caused because sufficient information is not apparent to decision makers when needed, though information to avoid them likely existed elsewhere. Governments are increasingly challenged because the cost of mistakes due to inadequate information seem to be escalating with time

At the same time, overall societal demand calls for better information quality and coordination, particularly as the globe gets "smaller." Governing roles in the United States are shared at federal, state, and local levels, while some public functions also are preformed by utilities and regional entities. Numerous governing actors often independently address and develop corresponding "stovepipe" information systems for the same or nearby geographic areas. IT proliferation causes a plethora of data to be available to state and local decision makers. However, when data from disparate systems are displayed geographically, redundant, overlapping, or conflicting data can be revealed to decision makers and the public. Growing awareness of data discrepancies stimulates demand for more precise, current, and accurate data, as well as improved intergovernmental coordination.

Demand for more effective and equitable governance and decision making is also growing, including use of better quality information to help solve society's increasingly interdependent, interjurisdictional, and complex problems. Simultaneously, citizens and other governments demand greater data access and input into decision making. Limitations on resources can stimulate government leaders to direct or encourage agencies to coordinate work with each other and external organizations, particularly concerning the use of GIT to meet these needs.

The nation's state and local governments are institutionalizing coordinated approaches to GI/GIT to address these issues and maximize resources, opportunities, and benefits. This article provides an overview of state and local government GI/GIT use and institutionalization as known today and challenges the GIT community to be proactive in designing and implementing future approaches.

The GIT community can help government leaders learn how GI/GIT can address many government issues and needs. Moreover, GIT professionals can encourage action by leaders to maximize GI/GIT opportunities and benefits within and across multiple organizations by authorizing, funding, and institutionalizing coordinated GI/GIT approaches.

Incidence and Use of GIT

An exposition of GI/GIT usage is occurring at all levels of the public, private, and not-for-profit sector. A recent panel of the National Academy of Public Administration concluded that GI "plays a role in about one-half of the economic activities of the U.S." (National Academy of Public Administration, 1998; p. 11). Beyond traditional natural and physical resource uses, government applications are emerging in human and social services, public health, public safety, criminal justice, emergency management, economic development, and growth management. Moreover, GIT is applied to many organizational activities, from policy analysis and development to planning, management, operations, regulation, adjudication, licensing, leasing, and other applications. GIT also supports business and financial functions in government, including analysis and optimization of revenues and expenditures, and particularly in collections and resource allocations.

Widespread GIT growth encourages institutionalization of government-wide GI/GIT approaches. But, it is important to recognize that, on the whole, governments have only recently begun to deploy GIT as part of government or department-wide business processes. The earliest state and local governments started using rudimentary GIT tools in the 1960s, but for many years usage was experimental or supported single-purpose needs, with limited resource allocations and few long-term commitments. Knowledge about local government GIT adoption has largely been anecdotal until recently, while more information has been documented over time about state governments.

State Governments

Several states started using GIT over 20 years ago. Approximately two thirds of them had used some GIT capabilities for one or more applications by 1980 (Cornwell, 1982) though some of these initiatives were experimental and not necessarily continued over time. For example, almost half of the known state GIT initiatives in the 1970s were not continued in the 1980s (Warnecke, 1987). An important trend in several states was the establishment of integrated natural resource information systems (NRISs). Inventories conducted in the early 1980s identified 16 to 19 functioning state NRISs, most with some GIT capabilities (Cornwell, 1982; Caron and Stewart, 1984).

Eleven state NRISs with GIT capabilities evolved to become government or department-wide systems that exist today. Most state departments of transportation (DOTs) had begun use of computer-aided drafting/design software for highway design and construction by the 1980s, and some also used this or GIS software for transportation planning. State GIT use expanded in these and other applications through the 1980s, with each of the 50 states known to have some GIS activity in at least one agency by 1990 (Warnecke *et al.*, 1992).

Additional applications emerging in the 1980s and expanding in the 1990s led to GIS now being applied in almost all functions of government by one or more states. Table 1 provides an overview of state agencies using GIS from an investigation almost five years ago, revealing significant penetration in

TABLE 1. GIS USE IN THE NATION'S STATE AND LOCAL GOVERNMENTS—CLASSIFIED BY LEADING AND SELECTED FUNCTIONS

Function	States[1]	Localities[2]
Revenue	26%	28%
Planning	24	58
Economic Development	40	33
Environment and Natural Resources		
Air	58	4
Water	98	9
Forestry	54	12
Public Lands and Parks	66	22
Infrastructure		
Transportation	100	41
Utilities	18[3]	38[4]
Public Safety and Emergency Management	48	28
Social, Human and Health Services	62[5]	9

Note: This table provides results from differing investigations, methods, and time periods and, thus, should only be used to show generalized and relative differences between state and local governments
[1]Adapted from Warnecke (1995).
[2]Adapted from Warnecke *et al.* (1998).
[3]Primarily utility service delivery
[4]Primarily utility regulation
[5]Primarily health applications

GIS use for natural resources and transportation (Warnecke, 1995). Informal comparison of these results with past research (Warnecke *et al.*, 1992) indicates continued expansion in these applications, but substantial growth in other "emerging" areas, such as public safety, emergency management, economic development, cultural resources management, and human or social services. Natural and physical resources data are increasingly complemented with socioeconomic data to newly understand critical societal conditions, such as disease, poverty, and crime. These issues can be top concerns of policy makers—often with receipt of strong political and financial attention and support that can simultaneously aid GI/GIT efforts in other areas. GIS use in these "emerging" areas can encourage integration of otherwise disparate data from several sources and strengthen government-wide GI/GIT coordination.

Local Governments

Measurement and understanding of GIT in local governments has long been a challenge as compared to states. However, knowledge about these conditions is increasingly needed for effective national GI/GIT policy, development, and maintenance. Limited query has occurred to measure GIT adoption in localities over time. However, a relatively greater level of usage is indicated in counties as compared to cities during the late 1980s, while adoption seems to have grown stronger in cities than counties during the 1990s (Warnecke *et al.*, 1998).

Several characteristics of local government jurisdictions are necessary to understand GI/GIT in local governments, particularly GI/GIT institutionalization. The country has more than 83,000 units of local government, including counties, municipalities, and townships, but also school districts and other special districts which account for almost 45,000 of this total. Special districts usually have singular or few functions, ranging from natural resources to fire protection, housing and community development, and others.

The roles of the three types of general purpose governments vary significantly across the country. The nation has over 3000 county government equivalents (including boroughs in Alaska and parishes in Louisiana), but a few states have no county governments (Connecticut, Rhode Island), and counties have limited roles in other states, such as where townships governments exist. Most counties serve relatively few people but have jurisdiction over large land masses. For example, 74 percent serve fewer than 50,000 people.

In addition to counties, more than 19,000 municipalities exist in the U.S. Almost half of all Americans reside in approximately 200 cities with more than 100,000 inhabitants. Of the remainder, more than 2000 serve between 10,000 and 100,000 people, and over 16,000 jurisdictions serve fewer than 10,000 inhabitants. Approximately 17,000 township governments are located within 20 of the 50 states, primarily in the Northeast and the Midwest. Serving as political subdivisions of counties similar to how counties are subdivisions of states, over 55 percent of the nation's townships have fewer than 1000 inhabitants, and only slightly more than 1000 have over 10,000 residents.

Local government functions, roles, and responsibilities vary significantly by state and region, with all of the above governments having important GI/GIT roles and activities in at least one state. For example, while townships serve few people as described above, they may have important roles and responsibilities in some states' local government as relevant to GI/GIT, such as property records management and assessment. Accordingly, the roles of a county can be those of a township or municipality elsewhere. School and special districts also may use GI/GIT and have important data roles, as well as regional entities such as councils of governments, metropolitan planning organizations (primarily to address transportation issues), and other regional planning organizations.

American and local government structure, level of professionalism, revenue generation capability, and additional factors across the broad range of jurisdictional types also have direct influence on GI/GIT adoption, applications, institutionalization, financing, and, ultimately, on success (Warnecke *et al.*, 1998). Moreover, nationwide analyses of local government GI/GIT investigation must consider that most Americans reside in and receive most of their services from one or more, but a small number of, jurisdictions simultaneously while the country's land mass is governed by many localities.

Nationwide local government GI/GIT investigations to date necessarily concentrate query on a limited body and number of jurisdictions, but results of these and any local GI/GIT investigations must be addressed in the context of the above conditions and issues. For example, two recent surveys of local GI/GIT conditions resulted in some differing, though explainable, results. In one nationwide survey of larger cities and counties, 77 percent of respondents reported that at least one department used GIS in 1996, with higher overall usage among larger jurisdictions, and in cities as compared to counties (Warnecke *et al.*, 1998). A larger nationwide survey of primarily counties found that 35 percent of these governments create, update, integrate, or distribute digital GI (National States Geographic Information Council, 1999). Both investigations revealed higher GI/GIT usage in the western U.S. than elsewhere. Further examination with careful attention to the above and other policy and institutional issues will lead to greater nationwide understanding of local GI/GIT conditions and needs.

Some information is available about GIS usage in localities. Key to understanding these conditions, and particularly if comparing levels of government, is that, with the exception of environmental and natural resources, localities have leading roles, authority, and potential GIT applications for a wider range of government functions than the federal or state governments. For example, provision or franchising of water, sewer, electric, gas, storm drainage, telephone, and/or cablevision utility services requires localities to maintain information about rights-of-way and the utilities located within them. Public safety is another traditional and leading responsibility of local governments, typically provided by sheriffs in counties and police departments in municipalities. Fire protection and emergency services also are provided by these governments and/or rural fire or other special districts. Moreover, localities are responsible for recordation and use of private land. They typically maintain information about land title, tenure, permits, subdivision, zoning, and planning for land within their jurisdiction, and exercise authority to plan for, determine, and accommodate future land uses.

Wide ranging local government roles and responsibilities are reflected in available findings about local GIS use. Planning is often found as a leading use (Budic, 1991; Juhl, 1993; Warnecke *et al.*, 1998); perhaps most frequently for comprehensive planning, and for zoning or subdivision review (Warnecke *et al.*, 1998). Respondents to these three local surveys also indicated strong GIS use in public works and utilities (often including transportation and engineering). A fast growth area is storm drainage/floodplain management (Warnecke *et al.*, 1998). Finance and tax departments are often indicated as strong GIS users in counties, but this survey interestingly also found strong GIS usage among larger cities. Similar to state government usage, GIS use is growing in "emerging" applications such as economic development. Moreover, public safety was indicated as the third most frequent application in large cities (Warnecke *et al.*, 1998). As indicated in Table 1, some localities also use GIS for less common applications, such as to address social and health services, and environmental and natural resources roles. The wide range of these local applications provides particular incentive for leaders to institutionalize government-wide coordination approaches to maximize resources and benefits.

Institutionalization

As GIT use accelerates and matures, multiple parts of the same jurisdiction may employ these technologies to meet their missions. Simultaneously, awareness within individual governments, and particularly among leaders, seems to be growing about the related GIT activities of nearby governments or utilities. Rising demand for accurate, current, and applicable data, and the need to reduce data redundancies, gaps, and costs, seem to be encouraging governments to coordinate GI/GIT activities.

These and several external factors discussed above can stimulate governments to institutionalize coordinated GI/GIT approaches to strengthen GI/GIT sharing and benefits, and meet multiple departments' needs with less resources. Many new coordination processes and mechanisms are forming, such as interorganizational groups, agreements, coordination staff, and clearinghouses.

However, institutional conditions are sometimes cited as "impediments," causing GIT results and benefits to be less than projected or possible. Limited investigation has been conducted about institutional conditions and factors, and the impact of GI/GIT on organizations, government, and intergovernmental relations. For example, Moyer and Niemann (1994) conclude that institutional factors are "one of the least understood, least discussed, and most important aspects" of GI/GIT (pp. 17–23). While many governments are taking action, institutionalization of coordinated GI/GIT approaches seem to be in its infancy both within and among many jurisdictions. Existing knowledge about state and local GI/GIT institutionalization is reviewed below—providing opportunities and ideas for GIT professionals to use in future advocacy.

Authorizing Direction

Enactment of authorizing direction is a leading component of GI/GIT institutionalization at all levels of government. A summary of federal GI/GIT direction and recent related activities is provided to help understand authorizing direction among the nation's state and local governments. This information is followed by a summary about state governments directives. Unfortunately, there is no known nationwide investigation about local governments directives, though examples are available of localities adopting ordinances and/or resolutions as GI/GIT policy instruments. Interlocal initiatives are typically authorized by memoranda of understanding (MOU) or agreement (MOA), or by contracts.

Federal Government

Early executive direction was set by the Office of Management and Budget through Circular A-16, updated periodically over recent decades. Most recently, Executive Order #12906, signed by President Clinton in 1994, urged the federal government to seek innovative ways to build a National Spatial Data Infrastructure (NSDI), including technology, policies, standards, and human resources necessary to acquire, process, distribute, and improve utilization of GI (Clinton, 1994). This direction is carried out by the Federal Geographic Data Committee (FGDC), which originated in the early 1980s to coordinate digital cartography among federal agencies.

Several limitations have been identified because national direction for GI is solely by Executive Order, particularly in *Geographic Information for the 21st Century: Building a Strategy for the Nation* (National Academy of Public Administration, 1998) and *Toward a Coordinated Spatial Data Infrastructure for the Nation* (National Research Council, 1993). FGDC recently invited representatives of state and local governments to participate, with four state and local groups now as *ex officio* members; however, the committee primarily remains federal in terms of direction and membership. Much progress has been made and over a dozen federal agencies have participated in FGDC for several years. However, multiple governments and agencies continue to develop and maintain data for the same geographic areas to meet individual mission requirements, and some federal agencies are known to essentially ignore FGDC standards and other direction. The Executive Order lacks sufficient strength and "teeth" to alter internal federal agency conditions to meet stated goals, and, in particular, to maximize connectivity with state and local governments. Moreover, separate federal direction and groups address remote sensing and the Global Positioning System (GPS). As a result, there are three separate federal policy approaches to GIT and no overarching legislative or executive direction, resulting in more challenges as these technologies are increasingly used together.

The Academy study recommended that federal legislation be enacted to establish a national approach and institutional infrastructure in order to more effectively lead and coordinate GI direction and activities. Legislative action was also recommended to move from voluntary federal agency participation to achieve greater connectivity, measurable results, and accountability, while enabling federal agencies to better synchronize goals, approaches, performance measures, budgets, and data development and maintenance plans with each other, states, localities, and others. The study's recommendations essentially lay dormant for a year and a half after release. However, they were a major topic of discussion at a hearing sponsored by the House of Representatives' Subcommittee on Government Management, Information and Technology 09 June 1999, particularly when Interior Secretary Bruce Babbitt announced his recent agreement with these recommendations. Drafting and discussions are underway to develop potential federal legislation, with the likely result providing a stronger state and local government voice and role in national GI/GIT policy.

State Government

Over time, more states have enacted authorizing direction for GI/GIT. Most official direction is provided through Gubernatorial Executive Order, similar to that signed by President Clinton, or more forcefully, by a state's Legislature. The statement of a high-ranking official, or a memoranda or understanding (MOU) or agreement (MOA) signed by agency leaders also has established GI/GIT direction in some states. A combination of multiple directives may direct or influence GI/GIT; occurring separately or in tandem with each other. For example, an investigation of GI/GIT authorizing directives in the 50 states funded by the Mapping Science Committee of the National Research Council in 1993 identified 100 directives among the 50 states, including (1) legislative action such as a statute, resolution, or budget or appropriations act; (2) executive direction such as an executive order or less formal directive; and (3) MOUs or MOAs which directly influence GI/GIS(Warnecke, 1993). Revealing increased incidence of executive and legislative action, almost half of these directives were authorized from 1991 to 1993.

State GI direction before the 1980s typically designated a lead mapping agency for state government, and/or created a state mapping advisory committee and/or geographic names board. This direction continues to exist in some states, though it sometimes is overshadowed by more recent action. Legislative and executive actions in the 1980s began to address coordination of digital data used with GIS, and some focused on broader definitions of GI and GIT. Several state directives, beginning about a decade ago, authorized interorganizational GI/GIT coordination and groups, sometimes provided for statewide service centers, or local or regional assistance, and, in selected cases, authorized GIS use to address specific programmatic needs. GI access and cost recovery issues also began to be addressed in legislation at this time. Ten of the 100 directives identified in the early 1990s investigation specifically addressed geographic data in modifications of open records

laws, generally including provisions for access and cost recovery, and sometimes provided direct reference to local government applicability, where this is a particularly strong issue (Warnecke, 1993).

The most common purpose of statewide GI/GIT authorizing directives today is to provide official sanction for coordination among state agencies, but also in some cases including external organizations, such as local governments, federal agencies, utilities, academia, and the non profit and/or private sector. These directives commonly authorize or recognize establishment of GI/GIT coordination groups, while some of them also authorize and fund related offices, roles, or data. Other state directives may uniquely provide assistance to local and regional organizations, and authorize GI/GIT use for legislative reapportionment (expected to increase with the 2000 census), and/or GI/GIT development for specific missions, such as water or natural resources management, environmental protection, or growth management. More funds seem to have been appropriated for statewide GI/GIT initiatives, staffing, and data development in recent years. In addition to these authorizing directives, states are establishing GI/GIT direction through the adoption of plans, policies, standards, and guidelines.

More and more state leaders are addressing GI/GIT, and the majority of the 50 states have some type of direction to facilitate or encourage statewide GI/GIT coordination among state agencies and others. However, far fewer than half of the states have enacted specific, comprehensive legislation in this regard, and particularly with funding (because direction by executive order typically does not provide for new funding). Moreover, few directives fully institutionalize GI/GIT within government, such as by requiring compatibility or sharing of state-funded data among agencies, establishing agency oversight through strategic planning or budgeting approaches to ensure compliance with direction, or directing the private sector or others to provide compatible data to use in permitted or regulated actions. Over time, there has seemed to be some increase in the enactment of direction that provides for such planning and management oversight of GI/GIT activities, particularly as synchronized with other forms of information technology, but this phenomenon has not been well documented to date.

Coordination Groups

As indicated above, encouragement or facilitation of interorganizational coordination can be a leading purpose and component of most state GI/GIT legislation and executive orders. One or more GI/GIT groups can be authorized or endorsed through such directives, or they can exist informally or by their own authorization. Over time, the growing incidence, authorization, and strength of these groups seems to reflect an increase in GI/GIT maturation and institutionalization. The groups also seem to encourage further institutionalization as they frequently build momentum and demand for data, services, and coordination instruments and mechanisms that often require established offices, staffing, and funding. Some investigation has been conducted about statewide GI/GIT groups, while information about related local groups is more limited.

State Governments

Today's state GI/GIT groups have evolved from both a history of related groups and a desire for coordination of GIS and other technology activities. Related directives before the 1980s created state geographic names boards and/or state mapping advisory committees (SMACs), both with encouragement from the U.S. Geological Survey. The names boards began in some states as early as 1900 to provide a forum to agree on place names, with 33 states having such a board by the mid 1980s. Names boards continue to operate today, but frequently in a separate manner from other GI/GIT groups, except for example in New Mexico and Texas. SMACs evolved beginning in the 1950s, and some continue to exist today with this title and focus on manual mapping as they were originally conceived. However, many SMACs have expanded in focus, merged with other statewide GI/GIT groups, and changed their names to include broader titles.

Informal state GIS user groups began to exist in the 1980s. Some governor's offices and other high level officials also started recognizing increased GI/GIT use then, serving to elevate policy attention and direction concerning GI coordination groups. The first state groups to address "geographic information" broadly emerged in the late 1980s, collectively known today as "GI councils" (GICs), though many are called "GI" or "GIS" boards or committees. For example, Oregon had two independent but related groups in the mid 1980s, each with an executive order. Made aware of overlap, the Governor issued a new order in 1987 for a broader or "umbrella" group incorporating the mission of both previous orders and groups. Some SMACs or GIS user groups evolved to become GICs while, in other states, the GICs emerged separately from these groups. Some combination of these three types of groups exist in some states today, with some operating separately from each other like the case of most names boards.

The trend toward GICs has grown during the 1990s, largely reflecting more comprehensive focus on data, and either direct or implied attention to multiple technologies and other interests in addition to that of state agencies. New formal and informal groups continue to emerge in the states, but during the 1990s, the trend is toward either one overarching group, or toward connected groups to be working together. For example, some states have a policy-level group with direction over one or more technical groups, sometimes focused on GIS, GPS, base mapping, standards, or other issues (Warnecke, 1993). States with multiple groups also may be differentiated by sectorial representation. An inventory of state GI groups conducted by this author in 1996 identified 88 independent groups whose leading charge addressed GI/GIT, with at least one in each of the 50 states, and up to four separate groups in a couple of states. It is expected that at least as many, or more, GI/GIT groups exist today among the 50 states than in 1996. A current investigation will identify state GI/GIT groups as of the end of the century.

The direction and configuration of state GI/GIT groups vary significantly, but this subject has not been a focused subject of analysis. Individual groups have unique and differing authorization, direction, resources, and participation, though they usually have similar objectives concerning GI/GIT coordination. There is a wide diversity in the level of GI/GIT policy or technical issues addressed by state groups. Overall, it can be surmised that these groups have experienced an increase in authorization, participation, strength, resources, and direct or implied responsibility and influence over the direction of GI/GIT in the states. When the last investigation of group authorizations was conducted, over 40 states were found to have at least one group with some degree of official stature, through statute (11), executive order (13), memoranda of understanding (2), or some other method (Warnecke, 1993).

An interesting known difference in the state GI/GIT groups is their memberships. Participants can include representatives of virtually all state government functions (similar to those agencies using GIS), though some functions are missing in each state's group(s). More and more members represent sectors in addition to state government. In order of general frequency, these may include localities, federal agencies, regional organizations, academic institutions, the business community, utilities, Indian tribal governments, non governmental organizations, and others. Localities seem to be the fastest growing membership sector, especially because they may be directly impacted and/or benefit from state GI/GIT activities. There also appears to be a trend toward increased establishment of new groups representing specific sectors operating in an individual

state, though these groups usually lack authorization by state direction. Some states have one group for each sector, with a particular increase in dedicated GI/GIT groups among localities (e.g., Colorado and Montana) and federal agencies (e.g., Florida, Kentucky, and North Carolina).

The organizational level of individual participants in state GI groups also varies considerably, ranging from agency directors in Florida, Kentucky, and North Carolina, to elected legislators or legislative staff, to mid- or policy-level agency officials or GIS users. Some states differentiate between voting and nonvoting members, with perhaps only state government representatives serving as voting members. Federal participation in state GI groups varies extensively among the states, with some states having no or only one federal representative, and others having multiple federal members. However, among groups established by statute, the existence of official federal membership and authority to vote is limited, which may have helped lead to separate federal GI/GIT groups that operate within some individual states. Linkages between separate GI/GIT groups operating within an individual state may or may not formally exist, thus providing some policy and coordination challenges.

State groups can have many important activities and impacts within state governments and other organizations. For example, they can impact the GI/GIT activities and coordination in localities, particularly because localities increasingly participate in state groups. Local participation in state groups can increase awareness and commonality across localities and also influence related state decision making and expand the awareness of state officials about local perspectives, issues, and needs. At the same time, local government involvement at the state level can stimulate growth in local GI/GIS groups and further GI/GIS institutionalization within localities, while encouraging compatible data development, data sharing, and other multilateral benefits among participating jurisdictions.

Florida: The Legislature established the Florida Growth Management Data Network Coordinating Council to coordinate information for growth management over a decade ago. Attention quickly evolved to concentrate on GI, followed by recognition of the need for coordination of GI for multiple state missions in addition to growth management. Accordingly, the Legislature replaced the Council in 1996 and established the Florida Geographic Information Board in the Executive Office of the Governor "to facilitate the identification, coordination, collection, and sharing of GI among federal, state, regional, and local agencies, and the private sector. The board shall develop solutions, policies, and standards to increase the value and usefulness of GI concerning Florida. In formulating and developing solutions, policies, and standards, the board shall provide for and consider input from other public agencies, such as the state universities, large and small municipalities, urban and rural county governments, and the private sector" (Florida Statutes Sec. 282.404(2)(a)). The Board is chaired by the director of planning and budgeting, and the members include directors or designees of several state agencies, and five representatives of local governments and regional entities (Sec. 282.404(3,4)). The statute also directs that the Board establish a second group to advise it, entitled the GI Advisory Council, also with legislated purpose and membership (Sec. 282.404(6–9)).

Kentucky: Increasing policy attention to the growth in GIS activity led the state General Assembly to act concerning GI/GIT. It established the "Geographic Information Advisory Council to the Kentucky Information Systems Commission" in 1994 to advise all three branches of state government and the Kentucky Information Systems Commission concerning GI and GIS (Kentucky Revised Statutes 61.958 (1)). The Council was directed to "establish and adopt policies and procedures that assist state and local jurisdictions in developing, deploying, and leveraging GI and GIS technology for the purpose of improving public administration." (2) and coordinate with GIS users "to establish policies and procedures that insure the maximum use of GI by minimizing the redundancy of GI and GI resources" (3). The council's duties also include "promoting collaboration and the sharing of data and data development, as well as other aspects of GIS (61.959(1h)), and overseeing the development of "a strategy for the implementation and funding of a statewide base map and GIS" (61.959(1b)); "and recommending standards on GI and GIS for inclusion in the statewide architecture" (61.959(1c)); and "the GIS training and education plan" (e). The Council includes 25 members and one legislative liaison, including the directors or designees of 15 state agencies, four representatives of local government, one representative of the Kentucky Chapter of the American Planning Association, one representative of the area development districts, and five private sector members, with a chair selected by the Council members (61.958 (4–5)).

Local Governments

Less is known about GI/GIT institutional approaches and groups within and among local governments than in states, though there is increasing evidence of their existence. In a 1996 survey of 200 counties and cities located across the United States, half of the respondents indicated that their jurisdiction has an internal interdepartmental GI/GIT coordination group (Warnecke, *et al.*, 1998). More larger cities (over 100,000 in population) indicated they had these groups than did other jurisdictions (75 percent), while only 37 percent of smaller cities (25,000 to 100,000) indicated having a group. Approximately two-thirds of the indicated groups were considered by respondents to be official in stature. Regionally, western localities most often reported having an internal GI/GIT coordination group.

This survey also found that almost as many reporting governments participate in a GI/GIS coordination group with one or more other jurisdictions as those which maintain an internal GI/GIS coordination group. Larger cities also represented the strongest response to participating in external GI/GIS groups. Western localities indicated strong involvement in external GI/GIS groups (90 percent), while only 38 percent of northeastern localities participate in these groups.

These findings clearly indicate that the incidence of local GI/GIT groups are less than state groups. There are likely several reasons, including less external stimulation and pressure to organize them. In addition, because states are administratively located between the federal and local governments, there has been more of a rationale for the establishment of groups at this level. These results may also indicate that, in general, the institutionalization and maturation of GI/GIT is less developed in local than state governments. While further measures are needed before such a conclusion can be made, these findings have direct implications on national coordination efforts.

Coordination Entities

Establishment of government-wide "focal-points," usually individual coordinator positions, offices, or other entities, are another important example of GI/GIT institutionalization that is stimulated by growing GI/GIT use and awareness. These entities typically facilitate, encourage, and otherwise carry out various roles, responsibilities, and activities regarding GI/GIT development and coordination as discussed below.

State Governments

Comparison of conditions in the 50 states indicates that GI/GIT coordinators are less prevalent than coordinating groups, though it is clear that more and more states are establishing coordinators. This was first characterized with the designation of one agency as the lead for base mapping (approximately one-third of the states), about ten state surveyors, about a handful of state cartographers, and in the late 1970s, a trend toward creation of integrated natural resources information systems (Warnecke, 1987). In some states, these designations continue today as the lead or in a supporting role for GI/GIT coordination. As shown in Table 2, as of 1985, only 17 of the 50 states were known to have an official or informal statewide GI/GIT coordinator (Warnecke, 1995). However, the number grew to 40 in 1991. In 1995, 41 of the 50 states had at least one coordinator, with nine of these states having GI/GIT coordination responsibilities shared by two organizations. The table also reveals that the number of coordinators authorized by legislation, executive order, or other policy-level action is increasing at a greater rate than coordinators in general. For example, the number of states with authorized coordinators more than tripled between 1985 and 1994, from ten to 31 (Warnecke, 1995).

An investigation has not been conducted about the incidence or authorization of state GI/GIT entities since 1995, though an update has been underway during 1999. Approximately two-thirds of the states are estimated to have officially established offices or positions to coordinate some aspect of statewide GI/GIT activities among state agencies, and often with localities, federal agencies, and others. Statewide GI/GIT coordination positions or offices established by legislation exist in Arizona, Arkansas, Kentucky, Massachusetts, Minnesota, Utah, Virginia, and Wisconsin. Additional states have an office serving informally in this role, so few state governments today do not have an acknowledged statewide focal point or more for GI/GIS coordination within their government bureaucracy.

The administrative location of state GI/GIT coordinators is important, and has varied by state and through time. As indicated in Table 3, the leading location for state GI/GIT coordinators in the 1980s was in agencies with natural resources or environmental responsibilities (Warnecke, 1995). However, the trend since is for the coordinators to be located in agencies with central or government wide roles, and particularly, those with oversight for information or information technology (IIT), with 18 located in these agencies in 1995. The number of coordinators located in planning, policy, or administration (PPA) agencies stabilized between eight and ten between 1988 and 1995. Importantly, 26 of the 41 state coordinators identified in 1995 were located in either of these types of central agencies.

TABLE 2. AUTHORIZATION OF STATE GI/GIT COORDINATORS

	Authorized		Unauthorized		
Year	Number	Percentage	Number	Percentage	Total
1985	10	59%	7	41%	17
1988	15	52%	14	48%	29
1991	30	75%	10	25%	40
1994	31	77.5%	9	22.5%	40
1995	33	80.5%	8	19.5%	41

TABLE 3. ADMINISTRATIVE LOCATION OF STATE GI/GIT COORDINATORS

Year	PPA	IIT	ENR	State	Non	Total
1985	4	0	11	2	0	17
1988	9	4	14	2	0	29
1991	10	12	14	4	0	40
1994	10	15	12	2	1	40
1995	8	18	12	2	1	41

PPA Planning, Policy, or Administration Agency
IIT Information Policy or Technology Agency
ENR Environmental or Natural Resources Agency
State Other State Government Agency
Non Non-State Government Organization

Moreover, 22 of these coordinators were authorized, compared to only four that were unauthorized. It is estimated that a few more of the official coordinators are now located within IIT agencies than at the time of the 1995 investigation. Location of GI/GIT coordinators in agencies with statewide focus provides additional evidence of increasing institutionalization of GI/GIT coordination in the states.

Local Governments

Information about the incidence and administrative location of GI/GIT coordinators in the nation's local governments is more limited than information about states, though there are some useful findings now, and more are anticipated in the future. Some state GI/GIT coordinators know about their counterparts, and some researchers have investigated localities in specific states or regions. Most information is available about county government, with less known about municipalities. For example, over half of Florida's 68 counties were found to have a central GIS organization in the mid 1990s (French and Skiles, 1996). Wisconsin law uniquely provides that counties must designate a land information office in order to participate in the Wisconsin Land Information Program, which has occurred in all 72 counties in the state.

A 1996 nationwide query of 200 counties and cities revealed over two-thirds of all reporting jurisdictions have a lead GI/GIS office, and over 70 percent have a lead person for GI/GIT (Warnecke *et al.*, 1998). Lead offices were more often identified in larger counties and cities, with 85 percent of the cities with over 100,000 inhabitants. However, less than half of the respondents indicated that the lead GI/GIS offices or individuals are officially designated, with the remainder sustaining these roles in an informal capacity.

Some local government studies investigate the administrative location of GI/GIT coordinators similar to analysis of state governments. Local government investigations are much more difficult than at the state level because of greater differences in departmental names, definitions, and functions across county and municipal jurisdictions; individual nuances in states; and the sheer variation among the country's local governments by size, ranging from those with millions of inhabitants to less than 100 residents. Some investigations nonetheless provide insight. For example, Budic (1993) surveyed approximately 125 local governments in Florida, Georgia, North Carolina, and South Carolina, finding that central GIS offices were most frequently located in planning departments.

The 1996 investigation cited above only queried about one point in time. Approximately 22 percent of both counties and cities indicated that lead GI/GIT offices were located in planning departments. Over 20 percent indicated that these offices are located in an information systems/technology (IT) office. Similar to the findings in states, more of the offices in the IT or independent department have official positions than those located in other types of departments. When an office was located in a functional department, then differences were found between

counties and cities. Public works or utilities departments were identified as the lead office in over a third of the cities, while they are the fourth most frequent location in counties. In addition, 8 percent of county GI/GIT offices were stated to be in finance/tax departments, while only one city stated that the lead office was located in this department.

Comparison of known conditions in state and local governments about the incidence and administrative location of GI/GIT coordinators is quite informative. While findings indicate that approximately 10 percent more of the states have a GI/GIT coordinator than localities, the percentage of states with them is similar to large cities. State and local differences seem to be more pronounced in terms of whether or not coordinators are officially designated, and where they are administratively located in government bureaucracies. While approximately two-thirds of the state coordinators are thought to be officially designated, less than half of the local government respondents in the 1996 survey were indicated to be official. These results just address the incidence and authorization of GI/GIT entities. However, the differences may infer that GI/GIT coordination is not as institutionalized or mature in localities as it is in states, similar to the incidence of GI/GIT groups. Differences in administrative location of GI/GIT coordinators support this notion, with more local GI/GIT coordinators located in functional departments than in central agencies where they are more often located in state governments. However, there could be a trend toward locating local GI/GIT offices in central and, specifically, IT departments, similar to conditions in states, but far too little historical data are available today to support this conclusion.

Government-Wide GI/GIT Roles, Responsibilities, and Activities

Most state and many local government-wide GI/GIT approaches increasingly provide for roles, responsibilities, and activities to be conducted by a combination of groups and coordination entities. Most government-wide GI/GIT approaches facilitate and strengthen the sharing and development of GI and some GIT among departments or agencies within and sometimes outside an individual government. Detailed analysis of official direction and individual conditions within individual governments would reveal several variations, such as in the level of centralization of these practices. This would include whether, or the degree to which, activities are conducted by a government-wide group or office, or by a super agency or large department.

Many GI/GIT coordination roles and activities may be performed by coordination groups or entities. Direction, roles, responsibilities, resources, level of effort, and effectiveness vary significantly by government and direction. For example, some GI/GIT entities concentrate on coordinating roles, while others primarily provide several services for agency or departmental clients. The following roles and activities have been identified as underway by one or more state GI/GIT offices (Warnecke, 1995):

- Serve as a clearinghouse concerning activities, projects, and plans about GI/GIT in state agencies and possibly other entities, including provision of directories, guides, annual reports, newsletters, and other materials with regularly updated information.
- Provide data clearinghouse, access, and dissemination functions for data indexed and possibly maintained in a state GI/GIT database, and perhaps provide customized data searches, manipulation, and interpretation to meet user needs.
- Develop and implement data and metadata policies, guidelines, standards, and procedures to encourage data commonality and sharing, including accuracy and scale requirements to meet overall state needs.
- Promote collaborative planning for future data development and other work, including helping prioritize, coordinate, and gather resources to develop and maintain data that is conducted by multiple organizations.
- Synthesize input from various entities to prioritize common data and other needs, gather resources to accomplish these needs, and carry out data development and/or acquisition plans.
- Develop data, sometimes with general appropriation or collaborative interagency funding to ensure data are useful for more than one purpose, project, or agency.
- Provide contract GIT services for state agencies and others.
- Staff GI/GIT coordination and user groups.
- Hold GI/GIT conferences and meetings to facilitate information exchange.
- Provide GIT educational services for state agencies and others.

In particular, FGDC advocates service as a data clearinghouse through the development of clearinghouse "nodes" and "area integrators" for data used with GIS. Approximately 30, or 60 percent, of the states are recognized to have at least one National Spatial Data Infrastructure (NSDI) clearinghouse node linked to FGDC. Fewer local GI/GIT clearinghouses seem to exist, with important implications from state and national perspectives in that the ability to access and aggregate local government data may be more difficult due to the lack of local institutional GI/GIT infrastructure.

Beyond data clearinghouse and technology service and coordination roles, some government-wide GI/GIT entities have specific planning and oversight roles, with some stronger than what currently exists in the federal government. For example, some states develop statewide GI/GIT plans, policies, or other guidance (with statutory, executive order, or no authorization), or prioritize and implement statewide data layers. States' direc-

Virginia: The General Assembly established the Virginia Geographic Information Network (VGIN) Division in 1997, then located in the Council on Information Management and now the Department of Technology Planning (Virginia Code Sec. 2.1–563.37). The division is led by a coordinator, who is directed to:

1. Oversee the development of and recommend to the Council the promulgation of those policies and guidelines required to support state and local government exchange, acquisition, storage, use, sharing, and distribution of geographic or base map data and related technologies.
2. Foster the development of a coordinated comprehensive system for providing ready access to electronic state government geographic data products for individuals, businesses, and other entities.
3. Initiate and manage projects or conduct procurement activities related to the development or acquisition of geographic data and/or statewide base map data.
4. Plan for and coordinate the development or procurement of priority geographic base map data.
5. Develop, maintain, and provide, in the most cost-effective manner, access to the catalog of Virginia geographic data and governmental geographic data users.
6. Provide, upon request, advice and guidance on all agreements and contracts from all branches of state government for geographic data acquisition and design and the installation and maintenance of GIS.
7. Compile a data catalog consisting of descriptions of GIS coverages maintained by individual state and local government agencies.
8. Identify and collect information and technical requirements to assist the Division in setting priorities for the development of state digital geographic data and base maps that meet the needs of state agencies, institutions of higher education, and local governments.
9. Provide services, geographic data products, and access to the repository at rates established by the Division.
10. Ensure the compliance of those pollicies, standards, and guidelines developed by the Council required to support and govern the security of state and local government exchange, acquisition, storage, use, sharing, and distribution of geographic or base map data and related technologies (Sec. 2.1-563.38B).

Kentucky: The General Assembly established the Office of Geographic Information in the Office of the Secretary of the Finance and Administration Cabinet in 1994, and created the position of executive director to head the office (Kentucky Revised Statutes Sec. 42.650(1)). The statute provides that the office shall:

(a) Establish a central statewide GI clearinghouse to maintain map inventories, information on current and planned GIS applications, information on grants available for the acquisition or enhancement of GI resources, and a directory of GI resources available within the state or from the federal government;
(b) Coordinate multiagency GIS projects, including overseeing the development and maintenance of statewide base maps and GIS;
(c) Provide access to both consulting and technical assistance, and education and training, on the application and use of GIS technologies to state and local agencies;
(d) Maintain, update, and interpret GI and GIS standards, under the direction of the council;
(e) Provide GIS services, as requested, to agencies wishing to augment their GIS capabilities;
(f) In cooperation with other agencies, evaluate, participate in pilot studies, and make recommendations on GIS hardware and software;
(g) Assist the council with review of agency information resource plans and participate in special studies as requested by the council;
(h) Provide staff support and technical assistance to the GI Advisory Council; and
(i) Prepare proposed legislation and funding proposals for the General Assembly which will further solidify coordination and expedite implementation of GIS (Sec. 42.650(1)).

tives typically advocate and encourage GI/GIT coordination, sometimes through the implementation of voluntary methods and incentives to encourage uniformity, such as policies, standards, guidelines, procedures, clearinghouse participation, etc. However, some state GI/GIT statutory authority goes beyond encouragement and voluntary mechanisms to require agency submission of data or information, monitoring of activities by statewide GI/GIT authorities, and/or agency compliance with statewide direction. Existence of these planning and oversight authorities is further evidence of GI/GIT institutionalization, but has not been investigated to determine need, use, or effectiveness.

State GI/GIT Assistance Programs for Localities

The authorization, establishment, and funding of local government GI/GIT assistance programs is an increasingly important part of state GI/GIT institutionalization. Development of local GI/GIT institutional infrastructures seems less mature than states as discussed above. Multiple departments in one jurisdiction may use GIT, but a mechanism may not exist for them to be aware of or complement each other's work, or that of neighboring localities. Many poorer governments and rural counties do not have sufficient resources to initiate GI/GIT efforts or develop data, causing a deepening divide between data-rich and data-poor communities. These conditions can impede data development for individual jurisdictions, but also data aggregation needed across boundaries for many regional issues such as land use or transportation planning.

At the same time, states recognize that more current, accurate, and precise data maintained by localities often can help them meet their programmatic needs. However, serious issues exist in most of the nation's local government in terms of financing GI/GIT, and many localities adopt data access policies to help recoup data development and/or maintenance costs. These policies can impede data relationships among neighboring governments and others, and even threaten governmental ability to respond to disasters and perform other government functions. At the same time, localities have important reasons to participate in state GI/GIT coordination activities and groups, such as to access state data and influence policies, standards, and program development. In sum, the needs of both state and local government are both incentives for states to help strengthen local government GI/GIT capacity and commonality. As described above, more states are inviting localities to join state GI/GIT groups. Moreover, several states have a tradition of helping localities build institutional capacity, such as in personnel and financial management, so it is a natural trend to extend help regarding GI/GIT.

It is estimated that about a quarter of the states have some type of local government GI/GIT assistance initiative beyond their general GI/GIT coordination efforts. There appears to be a growing incidence of these initiatives, generally categorized within three program types, including (1) a few specific programs specifically authorized by legislation for local GI/GIT; (2) some initiatives established to strengthen local government capacity and data to conduct planning and growth management (often by legislation); and (3) other activities initiated to help fulfill individual state agency missions, but which are, in effect, aiding localities more generally concerning GI/GIT. Participating localities may receive funding, technology, data, training, and/or other assistance from any of these state GI/GIT programs.

Few local government assistance programs are authorized directly for GI/GIT. An early example of these programs was when North Carolina began to provide funds to counties in 1977 for base and cadastral mapping, aerial photography, and uniform parcel identification numbering systems (though the program no longer has grant funds). State legislatures in other states have more recently provided funding for GI and use of GIS, such as New Hampshire and Utah. For example, Utah established a program in 1998 to help rural counties develop GI/GIS and, in 1999, to specifically develop right-of-way (ROW) data using GPS technology and aerial photography, in conjunction with the state geographic information database.

Perhaps the greatest financial expense and difficulty for localities is the development and management of automated, large-scale data. This is particularly the case for cadastral or parcel-level data needed for many local functions such as property taxation, development site review, building inspection, utility service, etc. Land records modernization is a key, but administratively difficult and expensive, need in local government and society in general. Some states have improved these local conditions through their property tax agencies, and a couple of states are investigating broader statewide approaches to land records modernization.

However, Wisconsin is the only state with an authorized and funded program specifically designed to help localities in this regard. Its legislature enacted acts in 1989 and 1990 to establish the Land Information Board and the Wisconsin Land Information Program (Wisconsin Statutes 15.105(16a-c), 16.967 (1–9)). The funding mechanism of increased title recording fees was established to be collected by counties, and counties were empowered to voluntarily establish land information offices in counties in order to receive program grant funds. All of the state's 72 counties voluntarily participate in the program, with over $50 million generated statewide for use by local governments since 1991 in retained fees and grants. Over the years, other states have tried to establish similar local programs in their states; however, Wisconsin remains unique because of its level of funding and specific purpose to modernize and develop local land information systems for multiple uses.

State planning and growth management legislation is the second type of program serving as a driver for local GI/GIT

development, in some states as directly provided in legislation, and in others, implemented by the state agencies having authority to work with their state's localities in this regard. Some of these programs have existed for over a decade. For example, both Michigan and Ohio established multimillion dollar programs in the early 1980s which provided counties with uniform digital maps of land-use conditions. The counties and others then used these uniform data within their own jurisdictions. More recent state planning and growth management laws can be credited with helping strengthen local GI/GIT development, such as in Florida, Georgia, Rhode Island, Vermont, and Washington. Funding has been provided in these states for technology, technical assistance, and/or data for regional or local GI/GIT activities.

The third type of state program helping localities concerning GI/GIS are operated by functional agencies, usually those with one or more environment or natural resources responsibilities, such as in Connecticut, Illinois, and New Jersey. GI/GIT connectivity between state and local agencies is also increasing in other functions of government. For example, New York's property tax agency has provided localities with software, standardized record formats, data definitions, and assistance in using GIS since the 1980s. Recently, some states have an active role in helping localities implement Enhanced 911 (E911) emergency communications service. E911 requires uniform, modernized addressing, and an increasing number of state GI/GIT service centers, such as in Maine, Oregon, and Vermont, have provided related assistance (Warnecke, 1995). State and local GI/GIT relationships also have been strengthened by federal funding and programs, as in transportation, emergency management, and community development. For example, the U.S. Department of Housing and Urban Development recently provided all the states and its community grantees with a suite of GIS software and data to help describe and implement programs.

Conclusion

GIS is increasingly viewed as an "enabling" or "transforming" technology, and a tool to "democratize data." It enables governments and others to better and more quickly understand, portray, communicate, and analyze existing and potential conditions from a geographic perspective. GI/GIT applications are now commonplace—and virtually essential—in government functions such as natural resources, environment, and physical infrastructure management and regulation. Moreover, GI/GIT use is emerging in new areas, such as social, human, and health services; public safety; and economic development. New combinations of natural, physical, and socioeconomic data combined with increasingly powerful GIT can stimulate unprecedented understanding of critical societal issues such as disease, poverty, and crime while encouraging vertical and horizontal coordination among governments. GI/GIT enables governments to more effectively, efficiently, and equitably define public policy, and plan and deploy government service. It also enables the public and other organizations to be better informed and more effectively involved in the governing process. Opportunities abound for greater participation and collaboration to reduce controversy and conflicts, and mitigate and jointly solve problems.

Future GI/GIT benefits and payoffs are beyond our ability to comprehend now—but the need for and challenges to coordinate efforts will clearly grow. Future attention, investigation, and action is suggested in the following four areas:

(1) Local and state governments are increasingly recognized as key participants in nationwide coordination and development of GI/GIT for several reasons. Governance trends in the U.S. clearly reveal increased delegation of federal responsibilities, coupled with growing state and local activism and self-governance. At the same time, increasing reliance on more precise and current data by federal agencies and others is putting more pressure on state, and particularly local, governments to produce, maintain, and provide access to their data. As described in this article, a suite of local governments provide a wide range of services for the public that necessitate development and maintenance of much "transactional" data. Automation, integration, and access to local data is increasingly desired by many organizations across society for governing, marketing, and other purposes. Yet, effective institutional approaches and financial mechanisms seem sorely lacking across much of the country. State governments are critical players in addressing the wide diversity among and range of local government responsibilities in the U.S. In particular, states create legal and operating environments for local governments, and can provide programs and mechanisms to strengthen data access and integration across local boundaries.

This article clearly reveals there is a growing need to better understand local government GI/GIT conditions, motivations, opportunities, and benefits to enable the federal and state governments to design approaches to aid localities and effectuate a nationwide approach. At the same time, demand is growing for qualified GIT professionals to serve in local governments.

(2) Evidence is growing that the promise of GI/GIT can best be realized with corresponding public leadership, official policy direction, and institutionalized internal and intergovernmental approaches (National Academy of Public Administration, 1998). This article reveals that coordinated, institutionalized GI/GIT approaches are emerging in the nation's states and localities. Benefits are beginning to be documented, such as (1) better access to better data; (2) greater GI/GIT awareness, access, and usage; (3) reduced data redundancy and conflict; (4) reduced individual project and data costs; and (5) better and more cost-effective decision making, management, and operations, both within and among governments. Official authorization of these approaches establish permanence, visibility, and stability, particularly needed with changing political and administrative climates, and create a buffer for coordination offices from "political and administrative uncertainties" (Challenger *et al.*, 1991, p. 6). While much can be accomplished through unofficial means, formal action can help ensure that GI/GIT direction and coordination is funded and maintained over time, because the goal of external coordination often suffers when organizations establish and allocate resources for internal priorities.

Moreover, looking to the 21st Century, it also is important to recognize that GI/GIT usage and institutionalization can stimulate fundamental institutional change in and among government organizations. Redundant, overlapping, or conflicting mandates and programs are revealed in ways unseen before GI/GIT was used, which may lead federal, state, or local leaders to reevaluate, and potentially eliminate, streamline, consolidate, or realign them. Significant institutional changes in terms of roles, responsibilities, and activities can result within and among agencies or governments. While such changes are just emerging in recent years, they are more likely in the future as governments are increasingly challenged to adapt bureaucracies to meet demands for greater efficiency and effectiveness in the information age.

As discussed in this article, institutional matters are among the least understood but most important aspects of GI/GIT. However, it is clear that institutionalized, funded, and long term state and local government GI/GIT strategies are needed to help develop and maintain baseline competence in GI/GIT across the country. GIT professionals have shown wisdom, foresight, and fortitude on many fronts in the past. An increasing challenge will be to carefully consider alternatives and advocate appropriate policy and institutional approaches as GI/GIT increasingly becomes a critical public and government resource. If GIT professionals are not proactive in this regard,

there is a growing risk that approaches will be authorized and adopted without appropriate input, possibly leading to unforeseen, unnecessary issues or problems.

(3) While much focus to date has been on technology, maturing adoption drives attention to data and, particularly, the need for accurate, current, and integrated information. Nationwide, one of the most critically needed sets of data for many purposes continues to be land ownership. An assessment of prior work describing the need for a "multipurpose cadastre" should be undertaken in the context of today's GIT and corresponding institutional approaches (see, for example, National Research Council (1980)). Management of land ownership data is clearly a local government responsibility, but there is a national interest, and potential federal and state government roles, to motivate improvements to benefit all. For example, Suzanne Hall, Assistant County Executive for Administration of Wayne County, Michigan explained at the House of Representatives' Subcommittee on Government Management, Information and Technology hearing on 09 June 1999 that several federal Internal Revenue Service agents regularly review these data at county offices. She recommended that the IRS agents could work much more cost-effectively if these data were better automated, accessible, and usable, and asked if the federal government could help finance such work. The beginning of the 21st Century is a perfect time to initiate dialogue on such fundamental issues, particularly because land ownership data are critical for many needs. For example, there is growing interest by all levels of government in more effective growth and emergency management which, in turn, requires attention to land ownership and use data.

(4) Finally, it is time to recognize and address that land ownership and many other data initiatives are constrained by financial limitations and issues. While our nation promotes a policy of freely available data, access and cost recovery issues are beginning to dominate many GIT discussions. However, the overall issue of GI/GIT finance has been long overlooked, and has not been well explored or articulated. Analysis of cost recovery in isolation of broader public finance issues is unwise because long term, workable solutions are needed. Much further investigation and analysis is needed to understand GI/GIT conditions, issues, needs, options, and opportunities from a public finance perspective. The beginning of the 21st Century is the perfect time to initiate new dialogue about broad public finance issues and to engage policy makers and public finance professionals and researchers to address this long term issue.

Financial investigations and other future GI/GIT initiatives in the 21st Century must be designed and implemented in the context of American governance. Challenges are clearly more institutional and less technical with time. The interests, perspectives, and needs of all levels of government must be addressed in the context of each other's emerging roles, responsibilities, and resources, with strengthened attention to local government—"where the action is." A strong argument can be made that states should use their general authority in establishing local government legal and operating environments to establish and fund voluntary, incentive-based programs to help localities build institutional and technical capacities to develop, use, and provide access to GI/GIT. Similarly strong arguments can be made for the federal government to help fund and institutionalize these programs, preferably in coordination with related state initiatives. Investigations and programs must consider existing and future relationships of all three levels of government to ensure data connectivity and "one-stop" approaches that society demands. Programs must ensure that a suite of benefits are realized, such as enhanced data integrity, access, usability, and usage across all boundaries and levels of government. The 21st Century provides many new and exciting challenges and opportunities for GIT professionals to help shape and implement institutional approaches to benefit all.

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Forthcoming Articles

M.M. Avard, F.R. Schiebe, and *J.H. Everitt*, Quantification of Chlorophyll in Reservoirs of the Little Washita River Watershed Using Airborne Video.

Jeffrey Barrette, Peter August, and *Francis Golet*, Accuracy Assessment of Wetland Boundary Delineation Using Aerial Photography and Digital Orthophotography.

Robert Bindschadler and *Patricia Vornberger*, Detecting Ice-Sheet Topography with AVHRR, RESURS-01, and Landsat TM Imagery.

Chang-Jo F. Chung and *Andrea G. Fabbri*, Probabilistic Prediction Models for Landslide Hazard Mapping.

Isabelle Couloigner and *Thierry Ranchin*, Mapping of Urban Areas: A Multiresolution Modeling Approach for Semi-Automatic Extraction of Streets.

M.K. Crombie, R.R. Gillies, R.E. Arvidson, P. Brookmeyer, G.J. Weil, M. Sultan, and *M. Harb*, An Application of Remotely Derived Climatological Fields for Risk Assessment of Vector-Borne Diseases: A Spatial Study of Filariasis Prevalence in the Nile Delta, Egypt.

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Jerome E. Dobson, Edward A. Bright, Phillip R. Coleman, Richard C. Durfee, and *Brian A. Worley*, A Global Population Database for Estimating Populations at Risk.

Peter Doucette and *Kate Beard*, Exploring the Capability of Some GIS Surface Interpolators for DEM Gap Fill.

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Joon Heo and *Thomas W. FitzHugh*, A Standardized Radiometric Normalization Method for Change Detection Using Remotely Sensed Imagery.

Paula F. Houhoulis and *William K. Michener*, Detecting Wetland Change: A Rule-Based Approach Using NWI and SPOT-XS Data.

Yishuo Huang and *Bon A. Dewitt*, Exploring Ground Truth from Given Photos by Applying a Model-Based Approach.

Minhe Ji and *John R. Jensen*, Continuous Piecewise Geometric Rectification for Airborne Multispectral Scanner Imagery.

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Hiroshi Kimura and *Yasushi Yamguchi*, Detection of Landslide Areas Using Satellite Radar Interferometry.

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Evaristo Ricchetti, Multispectral Satellite Image and Ancillary Data Integration for Geological Classification.

Gabriel B. Senay, John G. Lyon, Andy D. Ward, and *Sue E. Nokes*, Using High Spatial Resolution Multispectral Data to Classify Corn and Soybean Crops.

Jan Skaloud and *Klaus-Peter Schwarz*, Accurate Orientation for Airborne Mapping Systems.

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Jim Vrabel, Multispectral Imagery Advanced Band Sharpening Study.

Timothy G. Wade, James D. Wickham, and *David F. Bradford*, Accuracy of Road Density Estimates Derived from USGS DLG Data for Use in Environmental Applications.

Fangju Wang, Query Optimization for a Distributed Geographic Information System.

Jianjun Wang, Gary J. Robinson, and *Kevin White*, Generating Viewsheds without Using Sightlines.